Evaluation of fertilizer coating efficiency by NIRS and NIR hyperspectral imaging

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Introduction

Nowadays private industry launches new alternative forms of fertilizer on the market. One of them consists to apply a coating with humic and fulvic acids (HFA) on Diammonium Phosphate (DAP) fertilizer using a sticker. Rapid and non-invasive methods are needed to assess the quantity of HFA and the homogeneity of the coating. In this work, NIR spectroscopy and NIR hyperspectral imaging have been assessed for this purpose.

NIR spectroscopy

To measure the humic and fulvic acids (HFA) concentration, a classical NIR calibration was built using 10 samples ground with a known HFA concentration. Samples covering the range 1.5 to 2.4 % and wetted with sticker were prepared in the laboratory.

NIR Spectra of DAP + HFA ground

NIR Calibration (HFA)
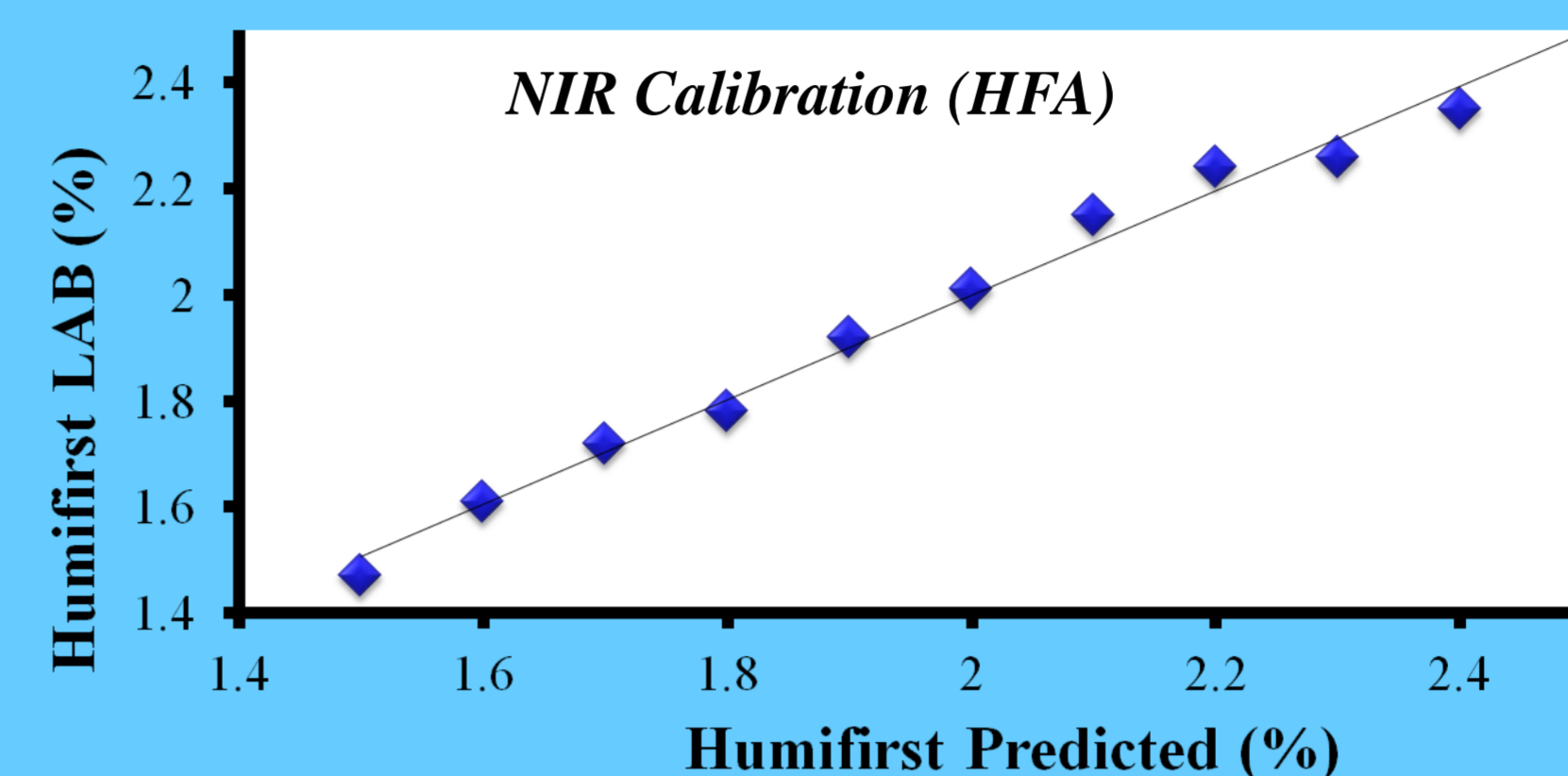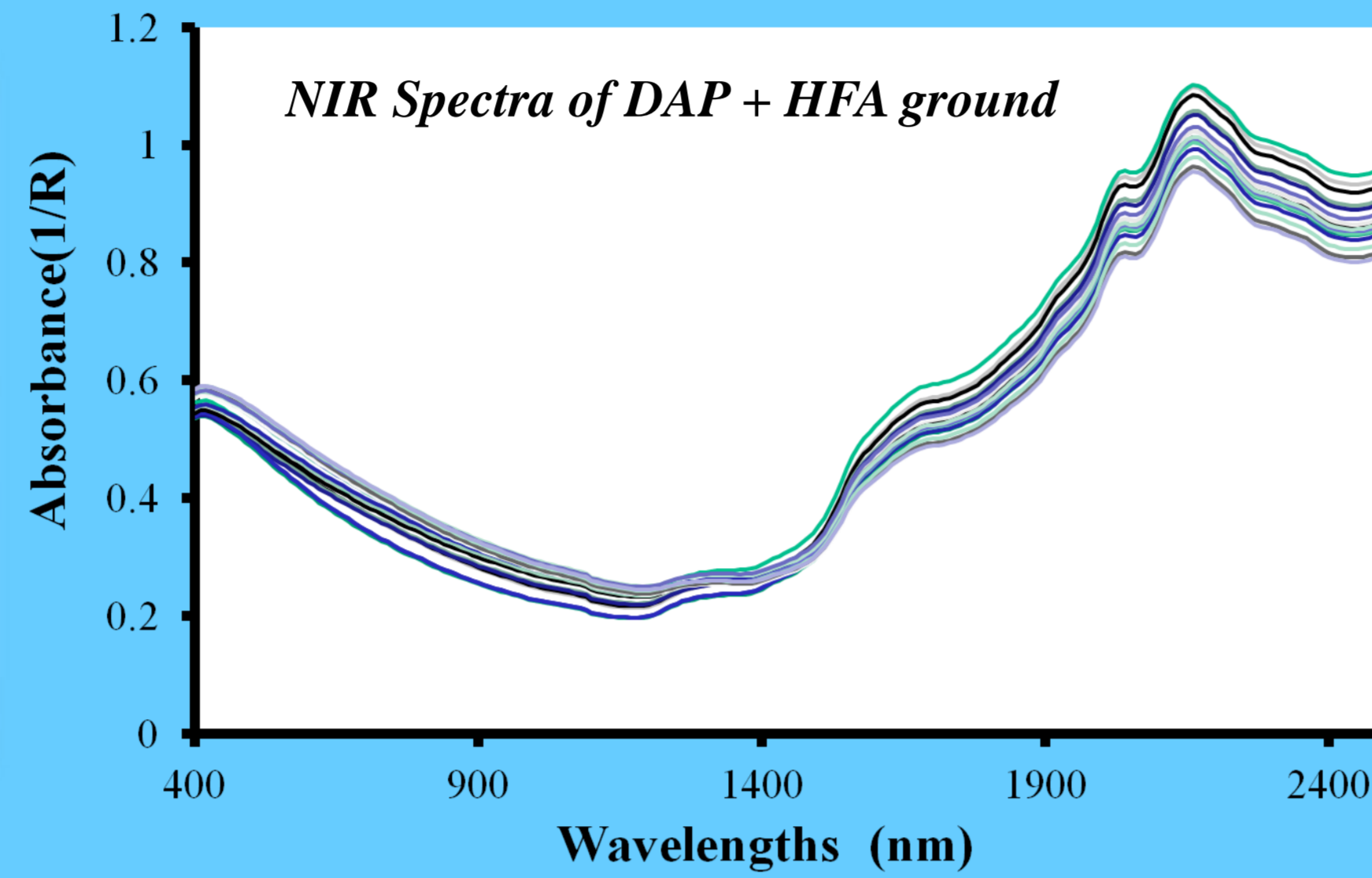
Parameter	Mean	SD	SEC	R²
HFA	1.95	0.29	0.05	0.97

The NIR calibration based on a MLR algorithm was validated with 4 independent samples covering the range 1.65 to 2.25% in HFA by showing a RMSEP of same order of magnitude as SEC and a RPD closed to 6.6 . This method requires the grinding of the fertilizer.

NIR Validation (HFA)
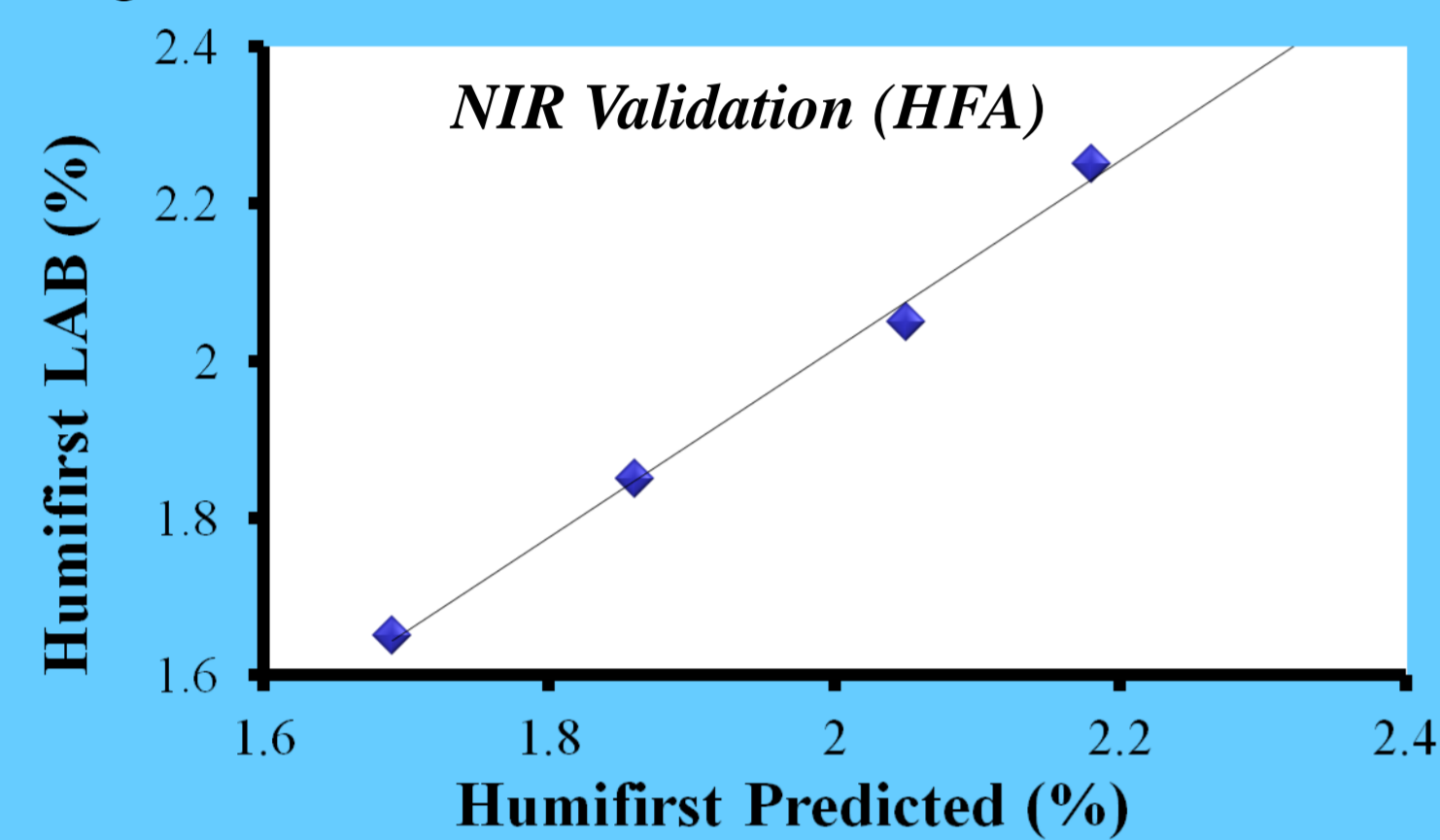
Statistic	Value	position	Sample No	LAB	Predicted
Number of Samples	4	1	DQ150100-11	1.65	1.69
Samples used for Statistics	4	2	DQ150100-12	1.85	1.86
Slope	1.196	3	DQ150100-13	2.05	2.05
Intercept	- 0.376	4	DQ150100-14	2.25	2.18
Bias	0.005				
SEP	0.039				
SEP (C)	0.045				
RSQ	0.996				
Predicted Average	1.945				
Actual Average	1.950				
Predicted SD	0.216				
Actual SD	0.258				
RPD	6.6				

2 others samples prepared in blind for the NIR lab have been also scanned on the spectrometer. The predictions were respectively 1.73 and 1.98 % HFA

Afterwards, it appeared that the real values were 1.7 and 2 % conforming the good quality of the calibration

## NIR hyperspectral imaging and homogeneity of the coating

To assess the homogeneity of the coating, 8 samples of Diammonium Phosphate (DAP) coated with sticker (V10/V20) and 1, 2, 4, 6, 8 or 10 % of humic and fulvic acid (HFA) were prepared and measured with a NIR hyperspectral line scan imaging system combined with a conveyor belt (BurgerMetrics).

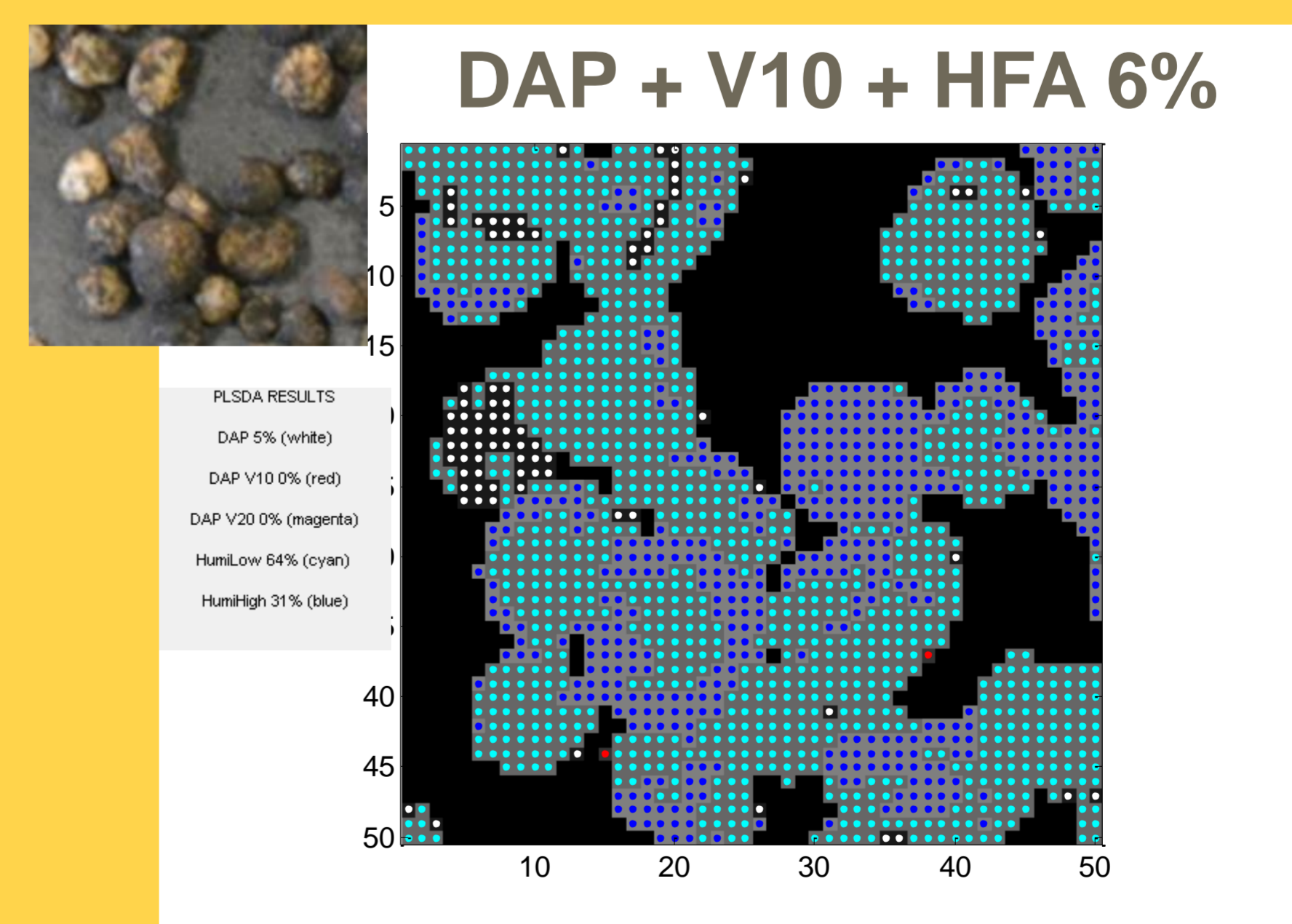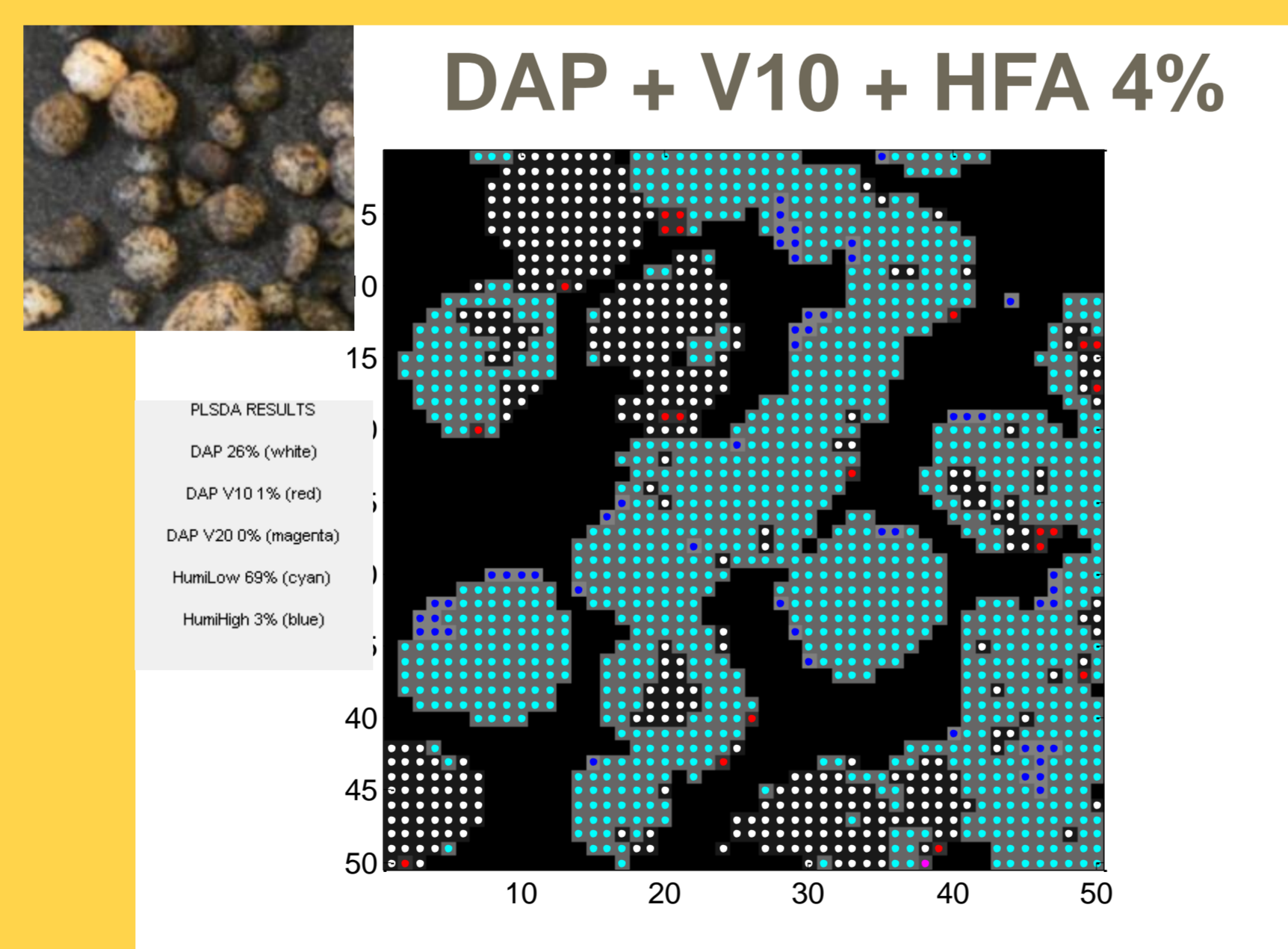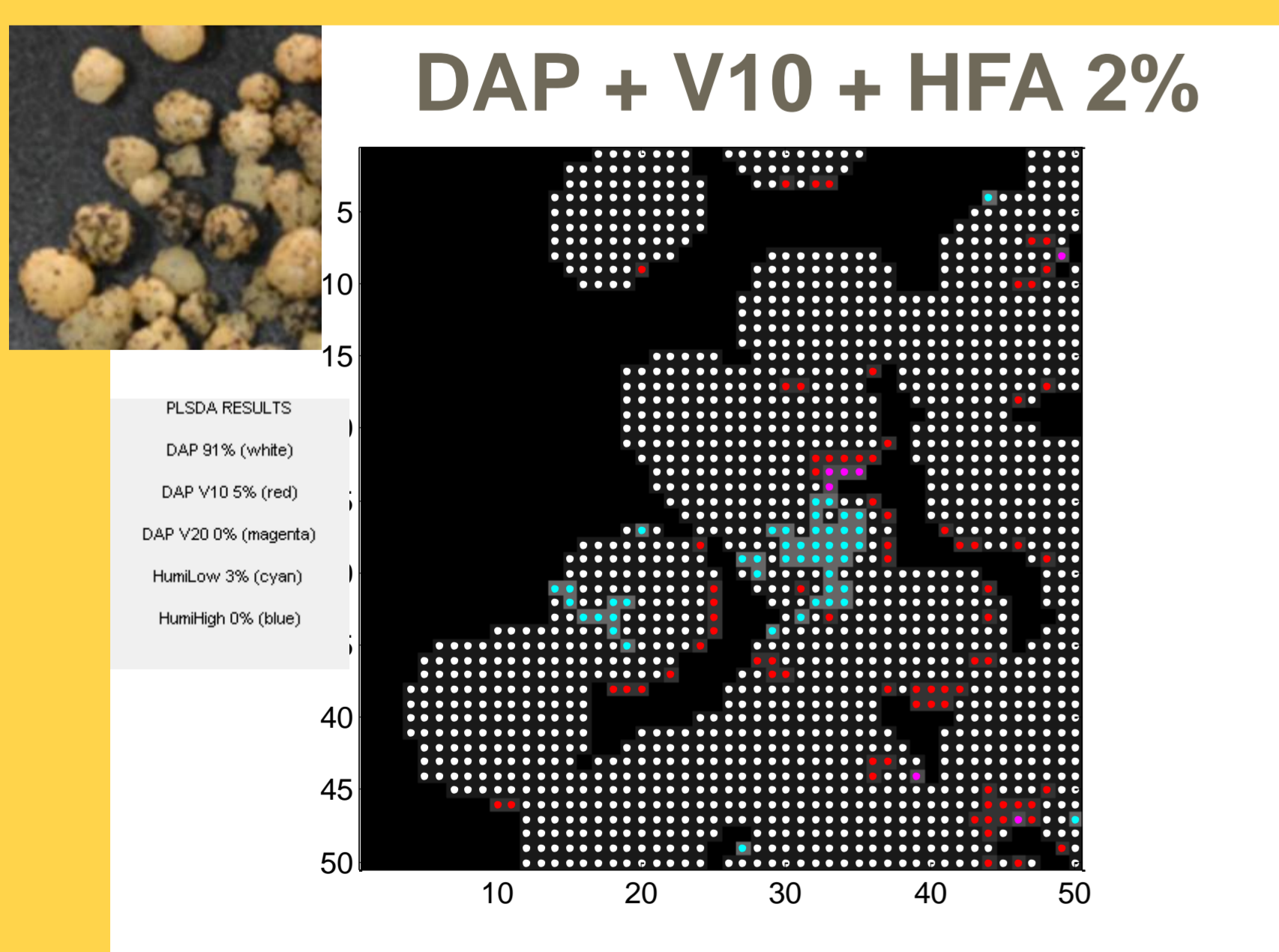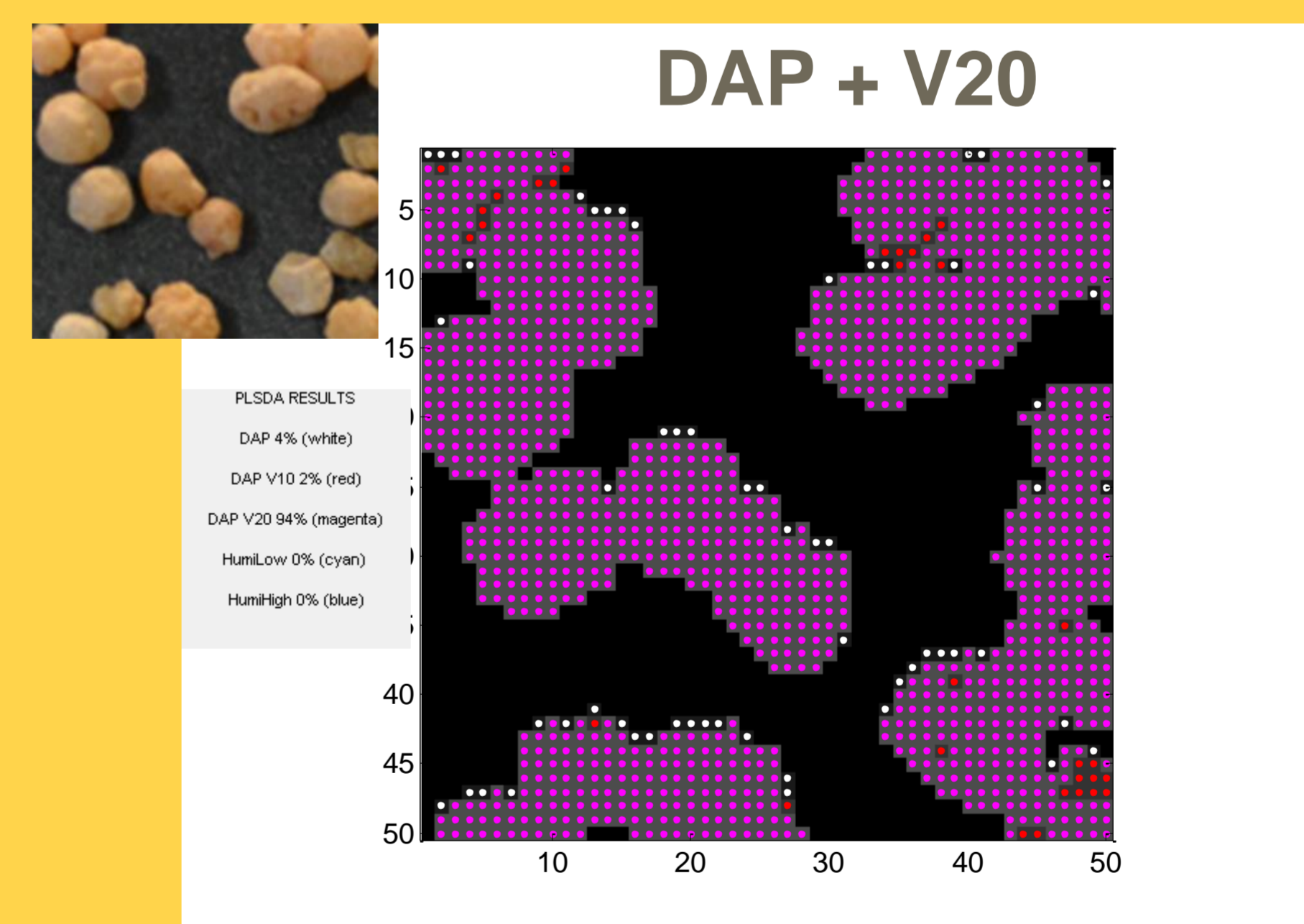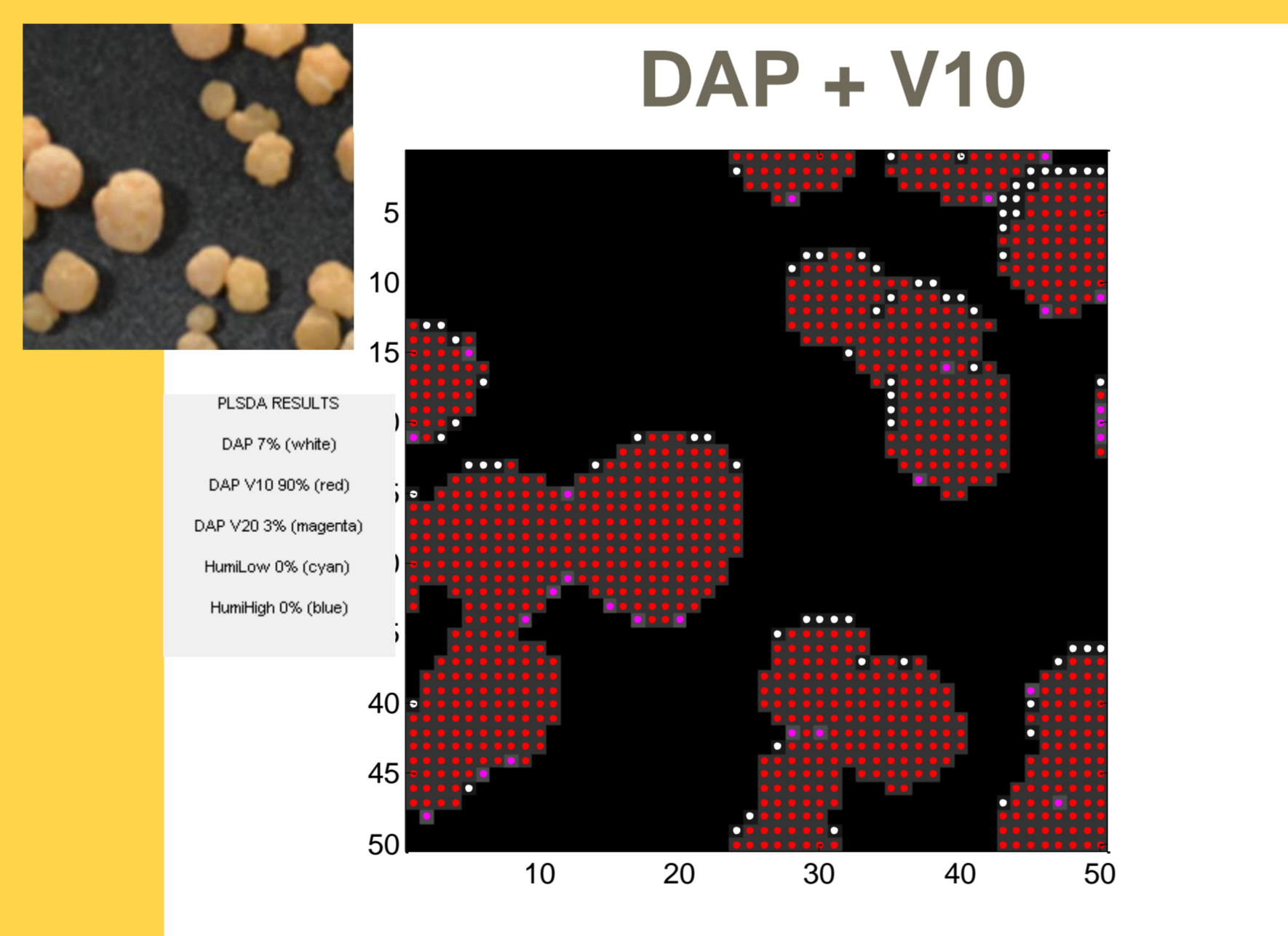Hyperspectral NIR imaging system with conveyor belt (Burgermetrics)
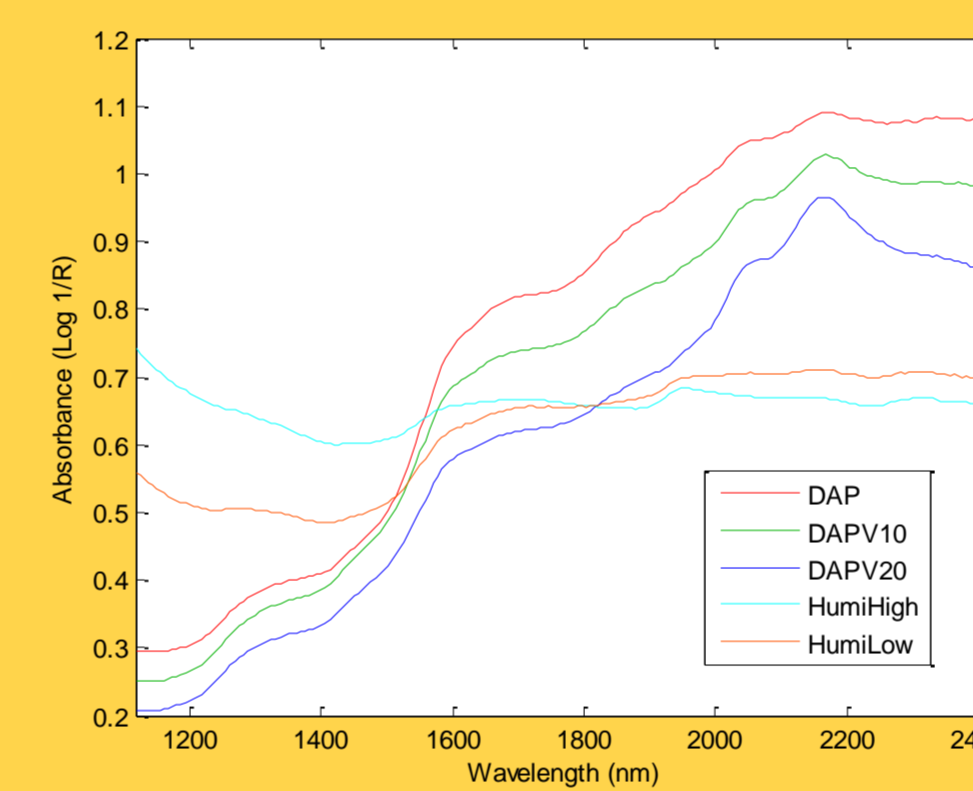
Typical spectra of DAP, sticker (V10, V20) and HFA (low, high)
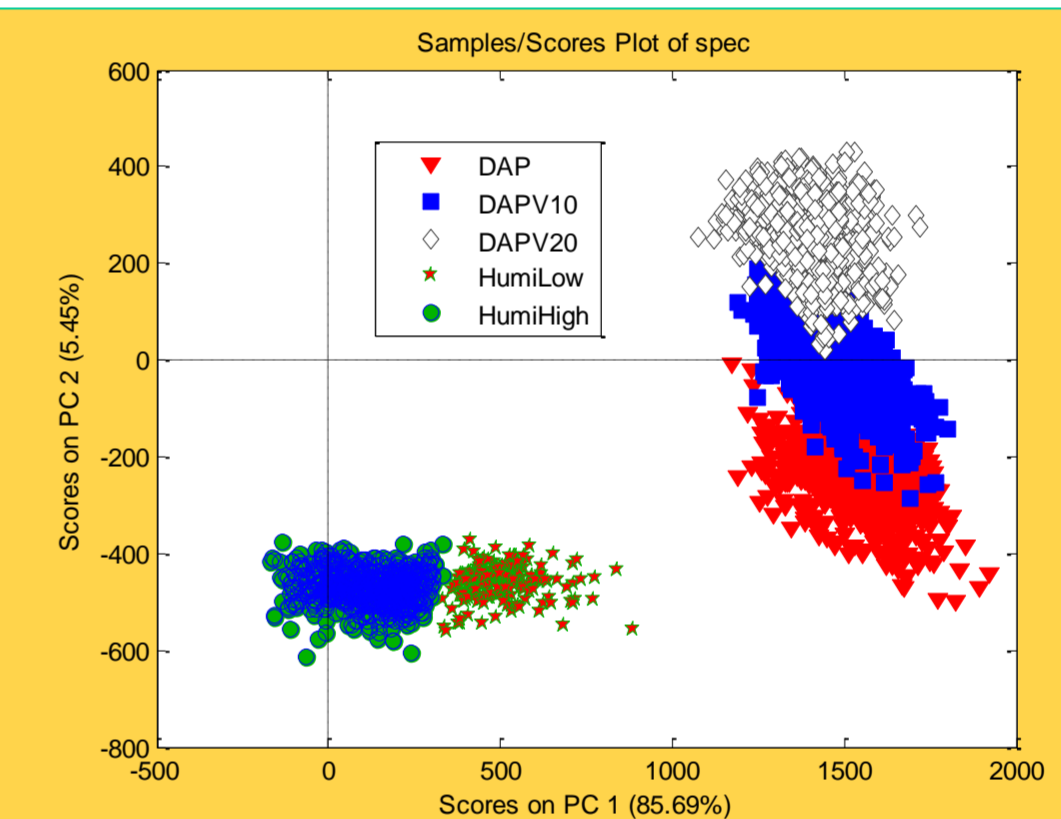
Scores plot (PC1/PC2) showing discrimination between DAP, sticker (V10, V20) and HFA (low, high)

To assess the efficiency and the homogeneity of the coating, the percentage of sticker and HFA had to be quantified particle by particle. All images consisted of lines of 320 pixels acquired according to the conveyor belt speed. Partial Least Squares Discriminant Analysis (PLSDA) was used as classification method for the construction of the discrimination models. It was applied to all the individual pixels in the images of the fertilizer samples in order to isolate and quantify the number of pixels detected as pure fertilizer (DAP), sticker and organic matter (HFA). The 5 figures to the right show RGB and predicted images for 5 combinations of DAP, sticker and HFA.

DAP + V10

PLSDA RESULTS
DAP 7% (white)
DAP V10 90% (red)
DAP V20 3% (magenta)
HumiLow 0% (cyan)
HumiHigh 0% (blue)

DAP + V20

PLSDA RESULTS
DAP 4% (white)
DAP V10 2% (red)
DAP V20 94% (magenta)
HumiLow 0% (cyan)
HumiHigh 0% (blue)

DAP + V10 + HFA 2%

PLSDA RESULTS
DAP 91% (white)
DAP V10 5% (red)
DAP V20 0% (magenta)
HumiLow 3% (cyan)
HumiHigh 0% (blue)

DAP + V10 + HFA 4%

PLSDA RESULTS
DAP 26% (white)
DAP V10 1% (red)
DAP V20 0% (magenta)
HumiLow 69% (cyan)
HumiHigh 3% (blue)

DAP + V10 + HFA 6%

PLSDA RESULTS
DAP 5% (white)
DAP V10 0% (red)
DAP V20 0% (magenta)
HumiLow 64% (cyan)
HumiHigh 31% (blue)

Conclusion

This study shows the potential of vibrational spectroscopy (classical NIR and NIR hyperspectral imaging) to propose solutions for the study of the coating efficiency of fertilizer. The quantity of organic matter coated on the fertilizer and the homogeneity of the coating can be assessed by this methodology. These methods can be used for the assessment of various processes linked to viability, quality and friability of coatings.

Acknowledgements

Walloon Agricultural Research Centre